Wind Farm Waste – Emerging Issues with Decommissioning and Waste Regulation in the EU, Denmark and the United Kingdom

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Wind Farm Waste – Emerging Issues with Decommissioning and Waste Regulation in the EU, Denmark and the United Kingdom

Ruven Fleming, Heyd Más and Ceciel Nieuwenhout

Abstract

26 years after starting operations, the first European offshore wind farm, Vindeby *in Denmark, is being decommissioned. The current article marks the occasion by examining current law and emerging practice on the decommissioning of offshore renewable energy installations in Europe. Its special focus lies with the frequently overlooked issue of waste disposal regulation after dismantling of offshore wind farms.*

The article is concerned with the interplay of waste and decommissioning rules. It analyses the waste hierarchy and other relevant concepts and norms of waste regulation in the context of decommissioning of offshore wind farms and investigates how the disassembled and removed components of offshore windmills have to be treated.

In addition, the article compares regulatory frameworks and practices on the management of waste from offshore wind farms under international law as well as in two countries with large installed capacities - the United Kingdom and Denmark. The waste disposal regimes and decommissioning programmes for offshore wind farms in both countries form the focal point of the analysis in this article. The article concludes with three recommendations on how to improve the international and national waste management arrangements for offshore wind farms. These recommendations pertain to the entire life-cycle of offshore wind farms, starting with the design phase right through to decommissioning and post decommissioning. The article, inter alia, proposes the inclusion of a new 'circular design' provision in relevant decommissioning regulation.

Introduction

'Windmills do not generate waste'[1]

Offshore wind farms play an important role in providing energy in a sustainable and economic manner. It is crucial to ensure that future increases in the demand for energy can be met with sufficient supply. Compared to other sources of renewable energy, offshore wind energy has the advantage that sufficient space for large wind farms exists, leading to economies of scale.[2] Moreover, at sea, the wind blows more hours per year, with a higher wind speed and more predictably than onshore.[3] European countries have discovered this and are currently developing offshore wind energy at high speed.[4]

However, it is important to consider that the renewable energy installations will reach the end

[1] Danish Environmental Protection Agency 'Waste in Denmark' 8, available at http://www.seas.columbia.edu/earth/wtert/sofos/Denmark_Waste.pdf [accessed 13/Oct/2017].
[2] Erich Hau, *Wind Turbines: Fundamentals, Technologies, Application, Economics* (3rd edn, Springer 2013) 677.
[3] Ibid.
[4] In 2020, there will be 24.6 GW of offshore wind capacity in Europe, and another 65 GW is in planning for the longer term. WindEurope, *Key Trends and Statistics 2016* (Wind Europe 2016) 24-25.

of their lifespan one day, when the developer decides that further operation is not economically viable or when the license period expires. Questions on the removal of the wind farm and the disposal of materials are increasingly relevant as many wind farms that started operations in the 1990s will make their final turn in the coming decade.[5]

Topham and McMillan stated that as 'decommissioning [of offshore wind farms] is a relatively new topic, there is not much legislation on it.'[6] Considering the amount of offshore wind farms that need to be decommissioned in the foreseeable future, there is, however, increasing pressure to clarify the rules for this activity. Luckily, a number of articles and studies have been published throughout the last years that dedicated themselves to the specific decommissioning regime of offshore wind farms.[7]

However, none of those discussed the particular issue of the management of waste stemming from decommissioned offshore wind farms. Although a comprehensive framework of waste treatment norms exists, its applicability to the decommissioning of offshore windmills has not been discussed much. This lack of attention in the legal literature is the reason why the current article focuses on the interlinkage between waste regulation and decommissioning norms. Its focal point is the treatment and management of waste that originates from decommissioned offshore wind farms, namely the components that have been brought to the shore after disassembly.

The article starts with a discussion of the definition of decommissioning and its relation to the treatment of waste resulting from the process. The article then provides an introduction to the waste hierarchy and other relevant concepts and norms of waste regulation. Afterwards, the international law framework for decommissioning is scrutinized with a view to its coverage of waste issues. The article assesses how the disassembled and removed components of offshore windmills have to be disposed of under this framework. Subsequently the article focusses on the national law level. A comparison of regulatory frameworks and practices on the disposal of offshore wind farms in two countries with large installed capacities - the United Kingdom and Denmark - will be provided. Due to the scale of installed offshore wind capacity both jurisdictions are likely to become central 'battlegrounds' for testing decommissioning and waste disposal regimes for offshore wind farms.

The United Kingdom is currently the largest developer of offshore wind energy in Europe,

[5] Within the next decade nearly 10 offshore wind farms have to be decommissioned and in the period between 2028 and 2038, these numbers are predicted to rocket to a statistical average of 4.6 offshore wind parks to be decommissioned every year. E Topham and D McMillan, 'Sustainable decommissioning of an offshore wind farm' (2017) 102 Renewable Energy 471 (hereinafter: Topham/McMillan).

[6] Topham/McMillan 472.

[7] Marie-Claire O'Hara 'The legal and regulatory framework governing offshore decommissioning' (2015) 31, 3 Construction Law Journal 122-138 (hereinafter: O'Hara); Topham/McMillan; David Pearson Enron 'Decommissioning Wind Turbines in the UK Offshore Zone' (2010) available at https://www.tib.eu/en/search/id/citeseerx%3Asid~oai%253Ads2%253Aciteseer%252F531e69aaaec718180a0297c5/Decommissioning-Wind-Turbines-In-The-UK-Offshore/#documentinfo [accessed 09/Oct/2017] (hereinafter: Pearson); Per Dannemand Andersen, Alexandra Bonou, Justine Beauson, Povl Brøndsted ~Recycling of windturbines' in Hans Hvidtfeldt Larsen; Leif Sønderberg Petersen (eds.) 'DTU International Energy Report 2014: Wind energy — drivers and barriers for higher shares of wind in the global power generation mix' (2014) Technical University of Denmark 91-97; Ontario Ministry of the Environment and Climate Change 'Assessment of Offshore Wind Farm Decommissioning Requirements' (2016) available at https://www.ontario.ca/page/assessment-offshore-wind-farm-decommissioning-requirements [accessed 9/Oct/2017] (hereinafter: Ontario).

hosting 40.8 per cent of Europe's installed capacity of offshore wind turbines.[8] The article presents the results of an analysis of eight decommissioning programmes of UK offshore wind farms that has been conducted by the authors. Moreover, it assesses UK waste laws for their applicability to offshore wind farm waste.

Denmark was a pioneer of offshore wind energy, starting as early as the beginning of the 1990s. Europe's first offshore wind farm, the Danish nearshore wind farm Vindeby, is now being decommissioned,[9] providing an interesting example of both theory and practice of decommissioning and a decommissioning programme with a focus on waste management in Denmark.

Definition of Decommissioning and Post-Decommissioning

A definitive legal terminology on decommissioning does not exist, which makes it difficult to understand what exactly is covered by the term 'decommissioning'. Neither does the term appear in major international law documents.[10] Despite the lack of a clear definition, the need to 'abandon' offshore platforms that are no longer in use is emphasized in all documents. The terms 'abandonment' and 'decommissioning' are often used interchangeably, but when one thinks of abandonment one thinks of leaving something behind whereas, in fact, the prevailing principle is one of removal.[11] It has, thus, been suggested that the term 'abandonment' does not convey a proper image of actions involved.[12] 'Decommissioning' seems to have a more comprehensive meaning than the term 'abandonment'.[13]

According to Topham/McMillan, decommissioning of an offshore wind farm can be divided into three different phases:

- project Management and planning (scheduling operations, costs and timing, etc.);
- the removal of the structures themselves;
- post-decommissioning processes such as the destination of the removed elements; or the monitoring of the sites' recovery.[14]

This article focusses on the third stage, the so called post-decommissioning phase. Under international law it is prohibited to just dump disused installations completely. Instead, operators have to use other ways to treat waste (including reuse and recycling) during the post-decommissioning phase. These ways (so called waste management) will be discussed now with a view to offshore wind farms.

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[8] WindEurope, *Key Trends and Statistics 2016* (Wind Europe 2016) 18.

[9] DONG Energy – owner and operator of the wind farm – has decided to decommission 'Vindeby' Offshore Wind Farm in March 2017. The world's first offshore wind farm consists of 11 offshore wind turbines and was connected to the grid in 1991. Information available at www.dongenergy.com (search 'Vindeby is retiring') [accessed 14/Aug/2017].

[10] See: BA Hamzah 'International rules on decommissioning of offshore installations: some observations' (2003) 27 Marine Policy 4, 339 (hereinafter: Hamzah).

[11] O'Hara 122.

[12] Wells can be 'abandoned', whereas installations and platforms have to be 'decommissioned', see: I Barclay et al. 'The Beginning of the End: A Review of Abandonment and Decommissioning Practices' (2001) Vol 13 Issue 4 Oilfield Review 28/29.

[13] Hamzah 339; Y Lyons, 'The New Offshore Oil and Gas Installation Abandonment Wave and the International Rules on Removal and Dumping' (2014) 29 Int'l J. Marine & Coastal L., 481.

[14] Topham/McMillan 472.

Waste Management and its Relation to Offshore Wind Farms

Given the focus of this article on the waste arising from decommissioned offshore wind farms, this section sheds light on the processes after the removal of renewable energy installations. The increasing number of offshore wind farms leads to a concern: the management of waste resulting from decommissioning those installations.

What is Waste Management?

It has been a long way in the evolution of the concept of waste management. In the early stages of urban life, waste had a much different composition and was managed in a much simpler, and often improper, way. The greatest advances on waste management happened during the nineteenth century. Formalized waste collection systems were then emerging driven by public health, and still are. Further, in the 1970s, environmental protection concepts were brought to the discussion and eliminating uncontrolled disposal of waste became a concern. It is then when technical standards are systematically increased. The value of waste has been increasingly taken into account, particularly certain streams that represent additional economic value. In today's society, the concept of waste management has developed much further from simply dumping and burying out of sight to the aim for a 'circular economy', the concept of a closed loop, where everything intended for disposal is reused, recycled or recovered. Basically, 'moving from the concept of "end-of-pipe" waste management towards a more holistic resource management.'[15]

The most recent advances in that direction can be seen in EU Law. Resulting from 30 years of evolution in European environmental law and policy, the revised Waste Framework Directive (WFD)[16] defines a set of rules for the proper management of waste in the EU and establishes specific waste streams as priority. The Directive primarily aims at reducing the environmental impact of waste and encourages resource efficiency by fostering the practices of reuse, recycling and recovery. In order to effectively achieve its goals, it includes structuring concepts such as 'waste hierarchy' (art 4), the 'polluter pays principle' (art 14), 'classification of waste' (art 7) and 'extended producer responsibility' (art 8). It also defines key expressions related to waste management (art 3): 'waste',[17] 'reuse', 'recycling' and 'recovery', among others.

The definitions provide more clarity on when waste should no longer be considered as such, and becomes a secondary raw material ('end-of-waste criterion'), and how the distinction between waste and by-products should be made. In sum, through specific definitions, principles and goals, the Directive established a legal framework for the treatment of waste within the European Union. By means of the five-step waste management hierarchy[18]

[15] DC Wilson, 'Development drivers for waste management' (2007) 25 Waste Management Res, 198.
[16] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives [2008] OJ L312/3.
[17] According to the current WFD 'waste means any substance or object which the holder discards or intends or is required to discard'.
[18] WFD preambulatory clause (31) 'the waste hierarchy generally lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy, while departing from such hierarchy may be necessary for specific waste streams when justified for reasons of, inter alia, technical feasibility, economic viability and environmental protection.'

introduced as a priority order, prevention should be the first option, followed by preparing for reuse, recycling and recovery. Disposal is strictly considered as a last resort.[19]

Waste Management for Decommissioned Wind Farms

1) Prevention

According to the WFD 'prevention' means measures taken before a substance, material or product has become waste.[20] The aim is to reduce: (a) the quantity of waste, including through the reuse of products or the extension of the lifespan of products; (b) the adverse impacts of the generated waste on the environment and human health; and (c) the content of harmful substances in materials and products.[21]

In this vein, repowering[22] (or refurbishment) and reuse of wind farms contributes to temporary prevention of a full-fledged decommissioning process and diversion of the waste from landfill.[23] The decision for repowering depends on various factors, including the size and type of project, its distance from shore, wind resource, regulations, power price, operating costs, and the extent to which existing infrastructure can be used longer.[24] Refurbishing can take the form of different processes and basically aims at restoring functionality to an 'as new' quality of wind turbines in their original setting.[25]

Prevention also includes reuse. Reuse and preparation for reuse are different concepts and are placed at different stages of the waste hierarchy. While reuse is generally associated with the prevention stage, preparation for reuse is seen as a distinct stage and will be discussed under the next heading. Reuse is applied to wind turbines that have not yet reached their end-of-life but can no longer serve the needs of their original park. They are sold as second-hand turbines to other wind parks. The second-hand market for wind turbines is recent, and in general, turbines either too small or too old for more mature markets are refurbished and sold

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[19] HF Más, *Transplanting EU Waste Law: The European Waste Electrical and Electronic Equipment Directives as a source of inspiration to Brazilian Law and Policy* (Vakgroep Bestuursrecht & Bestuurskunde Groningen 2016) 36. However, it is relevant to point out that even though the waste hierarchy establishes reuse and recycling as preferable to disposal 'there is little or no practical justification for considering that it is always preferable to disposal' according to JL Price and JB Joseph, 'Demand management - a basis for waste policy: A critical review of the applicability of the waste hierarchy in terms of achieving sustainable waste management' (2000) 8 Sust. Dev. 2. The role of the hierarchy is that of a theoretical framework and not a strict guidance catalogue. In the UK, for instance, DECC made a deliberate choice[#] and adopted the expression 'that developer should consider waste hierarchy'. This means developers 'should comply' and not 'must comply', a terminology demonstrating the need for flexibility to enable decision-making on a case-by-case basis, see DECC, 'Decommissioning of offshore renewable energy installations under the Energy Act 2004: guidance notes for industry' 2004, revised in 2011 page 24 (hereinafter: DECC Guidance).

[20] WFD, art 3(12).

[21] Ibid.

[22] Repowering can be partial (installation of a new drivetrain and rotor on existing tower and foundation to increase energy production) or full (replacing old turbines with newer/larger units) available at www.windpowermonthly.com/article/1349270/decommissioning-stay-go [accessed 08/May/2017].

[23] Most forecasts agree that the wind energy market will grow, both with respect to installed new capacity, repowering, and operation and maintenance. See: DTU National Laboratory for Sustainable Energy, DTU International Energy Report 2014: Wind energy - drivers and barriers for higher shares in the global power generation mix, eds. Hans Hvidtfeldt Larsen and Leif Sønderberg Petersen (November 2014) 38.

[24] Topham/McMillan 472.

[25] S Karavida and R Nõmmik, Waste Management of End-of-Service Wind Turbines (June 2015) Thesis Aalborg University, 44-45.

to Eastern Europe and Latin America.[26]

It is important to understand that reuse means to use products or components again for their original (or similar) purposes, where no significant changes to the physical status have been made.[27] Because reuse involves goods and materials before they become waste it is understood to fall within the waste prevention category.

In this context, ecodesign appeared as a key tool to encourage waste prevention. The concept was introduced in 2005 by the Ecodesign Directive (recast in 2009)[28] and focuses on improving environmental aspects during the conception and design phase of energy-related products. Ecodesigned products, according to the directive, should follow general and specific ecodesign requirements, consume less energy during the use phase as well as allow for easy recycling once discarded.[29]

As such, waste prevention is closely linked to the improvement of manufacturing methods because the way a product is developed has a crucial influence on the different stages of that product's life-cycle and, as a consequence, on the amount of waste it creates.[30] Therefore, investment in technological improvements to avoid the deterioration of materials and engines is of great relevance to increase the lifespan of a wind turbine, even beyond removal from its original location.[31]

2) Preparing for Reuse

'Preparing for reuse', according to the WFD, is something distinct from 'reuse'. It means 'checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be reused without any other pre-processing.'[32] Once waste prevention cannot be achieved, the waste hierarchy sets as priority the preparation for reuse. For wind turbines, this means that at this stage decommissioned wind turbines are to be repaired and, once ready, might be reintroduced in the market as used goods.

3) Material Recovery by Recycling

In the WFD, 'recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.[33] It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling

[26] K Daubney, 'Repowering trends enlivens second-hand turbine market' Wind power Monthly (June 2013) www.windpowermonthly.com/article/1183990/repowering-trend-enlivens-second-hand-turbinemarket [accessed 08/May/2017].
[27] WFD, art 3(13).
[28] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products [2005] OJ L191/29.
[29] Ecodesign Directive 2009, art 2(23).
[30] European Commission, *Being wise with waste: the EU's approach to waste management* (Luxembourg: Publications Office of the European Union 2010) 13.
[31] Kolios/Martinez-Luengo 109, 110.
[32] WFD, art 3(16).
[33] WFD, art 3(17).

operations.[34]

In general, the main materials identified to be used in wind turbines are steel, iron, glass fibre reinforced plastics, aluminium, and copper.[35] From the waste management point of view, the recycling process for metal is common practice and well developed.[36] Reports of the Joint Research Centre of the European Commission[37] show that a market exists for iron, steel and aluminium scrap to be used as feedstock in steel works, foundries, and aluminium refiners for the production of metals. Regulations were put in place to ensure that iron, steel and aluminium scrap resulting from recovery operations are sufficiently pure and meet the relevant scrap standards required by the metal producing industry.[38]

Another waste to be considered for recycling is the waste electric and electronic equipment (WEEE). According to the WEEE recast Directive[39], EEE which is not specifically designed and installed as part of large-scale fixed installations falls within the scope of the provisions for the take-back of WEEE solution (this refers for instance to lighting equipment). The 'take-back' system for a specific waste stream includes reverse logistics of the end-of-life product, the idea being that all things involved in the life cycle of the product should be taken back.

The WEEE recast Directive explicitly excludes 'large-scale fixed installations', such as wind turbine stations (including their cabin, wings, equipment in tower, cranes), from its scope from 2018 onwards.[40] The focus of the producer responsibility is shifting towards electric and electronic products purposed for household use.[41]

Certain cables do fall into the scope of the WEEE recast Directive, but there are a few criteria to follow in order to verify if cables indeed must be treated according to this Directive. This concerns the rated voltage of the cables, and the type of supply routes. The WEEE recast Directive only applies to EEE with rated voltage of <1 kV AC and <1,5 kV DC (art 3(1)(a)). If cables are supplied for Large Scale Fixed Installations (LSFI), for other excluded purposes (art 2(4)) or as equipment for the protection of essential interests of security of Member States (art 2(3)), these cables do not fall under the scope of the WEEE recast Directive. Thus,

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[34] Ibid.

[35] P Garrett and K Ronde, 'Life Cycle Assessment of Electricity Production from a V90-2.0 MW Gridstreamer Wind Plant' (Vestas Wind Systems A/S, Randers 2011) 40-44.

[36] See: C Hagelüken, 'Recycling the Platinum Group Metals: A European Perspective' (2012) 56 Platinum Metals Rev. (1), 29-35. RU Ayres, 'Metals recycling: economic and environmental implications' (1997) 21 Resources, Conservation and Recycling 145-173.

[37] L Muchová and P Eder, *End-of-waste Criteria for Aluminium and Aluminium Alloy Scrap: Technical Proposals* (Luxembourg: Publications Office of the European Union 2010) and L Muchová and P Eder, *End-of-waste Criteria for Iron and Steel Scrap: Technical Proposals* (Luxembourg: Publications Office of the European Union 2010).

[38] Council Regulation (EU) No 333/2011 of 31 March 2011 establishing criteria determining when certain types of scrap metal cease to be waste under Directive 2008/98/EC of the European Parliament and of the Council, OJ L94/2. Commission Regulation (EU) No 715/2013 of 25 July 2013 establishing criteria determining when copper scrap ceases to be waste under Directive 2008/98/EC of the European Parliament and of the Council, OJ L201/14.

[39] WEEE Directive.

[40] WEEE Directive, art 2(4)(b) states that any equipment that is not specifically designed and installed as part of a large-scale fixed installation does not benefit from this exclusion. Lighting equipment is normally not specifically designed to be part of a specific installation, and is therefore in scope of the Directive.

[41] BIO Intelligence Service, 'Review of the scope of the Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), Final report prepared for European Commission - DG Environment (2013) 23-24.

it can be concluded that only very minor components of a wind turbine are subject to the regime of the WEEE recast Directive.

Regarding recycling, the so called 'extended producer responsibility' becomes increasingly important. There is a tendency in emerging waste legislation to place the onus on producers, which are expected to invest in technology and design for waste prevention and recycling as well as become financially responsible for the reverse logistics. This is an important factor in 'closed loop' recycling, which can be observed, for example, in electrical equipment and vehicles, respectively, in the WEEE and the ELV (End of Life Vehicles) Directives. The take-back provision of WEEE (and ELV) instigated a new trend in EU waste law. In these waste streams, manufacturers, distributors, consumers, recyclers, and logistics companies were included in the closed loop for the take-back. Clear roles and responsibilities were negotiated and included in this structure which facilitated the development of sustainable methods (and technological challenges were overcome).[42]

This closed loop-case of the WEEE and ELV Directives could serve as inspiration to the development of the waste management framework of offshore wind turbines. Learning from the described take-back systems which are incorporating the producer responsibility principle, collaboration between producers and recovery industry could be established. Under this model, manufacturers should develop their products with a focus on design for recyclability.[43] The roles and responsibilities for different actors involved in the supply chain of offshore wind turbines should be further clarified and the structure for the take-back system should be discussed and settled.

4) Recovery (other than recycling)

According to the WFD 'recovery' means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.[44] Annex II of the WFD sets out a non-exhaustive list of recovery operations.

Out of this non-exhaustive list, a main example of recovery other than recycling is energy recovery. Regarding offshore wind turbines, (scarce) examples of recovery are the usage of crushed wings as input in the cement production industry[45] and the usage of macroalgae (seaweed) from underwater parts of the foundation as a fertiliser in agriculture.[46]

5) Disposal

Last in the waste hierarchy, the WFD defines 'disposal' as 'any operation which is not recovery even where the operation has as a secondary consequence the reclamation of

[42] R Cherrington, V Goodship, J Meredith, BM Wood, SR Coles, A Vuillaume, A Feito-Boirac, F Spee, K Kirwan, 'Producer Responsibility: Defining the Incentive for Recycling Composite Wind Turbine Blades in Europe' (2012) 47 Energy Policy 13, 18 (hereinafter: Cherrington and others).
[43] PD Andersen, A Bonou, J Beauson, P Brøndsted, 'Recycling of wind turbines' In *DTU International Energy Report* (2014) 96.
[44] WFD, art 3(15).
[45] GEO, 'Technik: Wie entsorgt man Windkraftflügel?' available at www.geo.de/GEO/technik/63335.html [accessed 08/Jun/2017].
[46] See *infra* footnote 110.

substances or energy.'[47] The Directive includes in its Annex I a non-exhaustive list of disposal operations, of which landfill is the most commonly known.

Studies on the topic of decommissioning of wind turbines showed that the blades pose the greatest challenge to the recycling and proper destination of end-of-life wind turbines.[48] Although the treatment of end-of-life wind turbine blades is not yet specified in EU legislation,[49] disposal of waste is to be avoided according to general waste rules. In line with the WFD waste hierarchy, the 7th Environment Action Programme sets as one of its priorities to phase out landfilling to non-recyclable and non-recoverable waste.[50] Despite this focus of the European environmental policy to reduce waste production, maximize reuse and recycling, limit incineration (without energy recovery) and landfilling, the Landfill Directive does not ban (art 5(3); annex II) the disposal of fibre-reinforced polymers, which are mainly used in the wings of offshore windmills. Still, while landfills remain the least expensive option, there is a growing expectation[51] that more Member States pass laws forbidding landfill disposal of composites.

Adding to the problem, composite recycling is challenging and energy recovery (incineration) is limited.[52] For fibre reinforced polymer composites or plastics (which the blades of wind turbines are made of) there are few options of mechanical shredding, and thermal processing techniques are costly. Incineration can only recover the calorific value of the material that is provided by the organic fraction within fibre reinforced composites. So far, the costly procedures, lack of market and better techniques all lead to landfilling as the most cost-effective option.[53]

Another point of concern is the toxins contained in parts of the turbines that are released when the materials are recovered or incinerated at extremely high temperature. For instance, hazardous waste can be found in the nacelle (steel alloys). Further, the material of the blades, fibre reinforced plastics, is a resin that develops toxic gases and must be filtered carefully.[54] Additionally, the dust produced by cutting the blades creates a hazardous working environment.[55]

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[47] WFD art 3(19).

[48] See: PD Andersen, M Borup, T Krogh, 'Managing long-term environmental aspects of wind turbines: A prospective case study' (2007) 7 Int. J. Technol. Policy Manag., 339-354; N Andersen, O Eriksson, K Hillman and M Wallhagen, 'Wind Turbines' End-of-Life: Quantification and Characterisation of Future Waste Materials on a National Level' (2016) 9(12) Energies.

[49] Cherrington and others 20.

[50] Annex to the Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' (the 7th Environment Action programme' or '7th EAP').

[51] See: DR Vieira, RK Vieira, MC Chain, 'Strategy and management for the recycling of carbon fiber-reinforced polymers (CFRPs) in the aircraft industry: a critical review' (2017) 14(3) International Journal of Sustainable Development & World Ecology; G Oliveux, LO Dandy, GA Leeke, 'Current status of recycling of fibre reinforced polymers: Review of technologies, reuse and resulting properties' (2015) 72 Progress in Materials Science.

[52] Cherrington and others 14.

[53] PD Andersen, A Bonou, J Beauson, P Brøndsted, 'Recycling of wind turbines' In Hans Hvidtfeldt Larsen and Leif Sønderberg Petersen (eds) *DTU International Energy Report 2014 Wind energy - drivers and barriers for higher shares in the global power generation mix* (DTU National Laboratory for Sustainable Energy 2014) 93 (hereinafter Andersen, Bonou, Beauson and Brønsted).

[54] See: GEO, 'Technik: Wie entsorgt man Windkraftflügel?'available at www.geo.de/GEO/technik/63335.html [accessed 08/Jun//2017].

[55] Andersen, Bonou, Beauson and Brønsted 94.

Because of the features of this type of waste, legislation on the disposal of hazardous wastes in Europe would be applicable to offshore wind turbines.[56] Hazardous waste legislation became stricter over the last decades in the EU, mainly influenced by the Directive on Hazardous Waste 91/689.[57] As an unfortunate consequence, certain producers of hazardous waste have found cheaper alternatives. Because developing countries in general have less-strict regulations, they have been turned into an attractive destination for disposal.[58] Hazardous waste has been imported and disposed of under unsafe conditions and even without permission in different incidents.[59] From a legal point of view, every state has the sovereign right to ban such imports, but if the bans are unilateral the result is unlikely to be effective[60] and many States do not have the necessary resources to enforce such bans.

To tackle the issue, Council Regulation (EEC) No 259/93 of 1 February 1993 applies to the international shipment of waste within, into, and out of the European Union. The regulation has been amended on several occasions and adopts the OECD Decision C(2001)107/Final on the control of transboundary transports of wastes, as well as the Basel Convention on the control of hazardous wastes and their disposal, along with other provisions of EU law.[61]

To sum up, existing practices and options for waste management are by and large applicable to the post-decommissioning of offshore wind farms.[62] Lessons to be learnt include an increase in the sharing of data on the amounts of waste estimated and produced as well as the dynamics of processes that are already in use. Those are necessary actions to be taken in order to properly manage waste from decommissioned wind farms. Moreover, the waste hierarchy, manufacturing with design for reuse and recycling (especially as seen necessary for the blades), and establishing proper reverse logistics structures, where roles and responsibilities are made clear, should be adopted. This would follow the emerging trend for a closed-loop of products life-cycle, that is, a circular economy that takes into account everything that is produced, which, when no longer used, should be fully reintegrated into the economy. For wind turbines to be treated in this way, 'ecodesign'[63] or as more recently called 'circular design'[64] of offshore wind turbines should be made obligatory for turbine producers. The following sections will now check to which extent the legal framework for the decommissioning of offshore wind farms takes account of these waste management

[56] See, for instance, DECC Guidance 5-6.

[57] Council Directive 91/689/EEC of 12 December 1991 on hazardous waste. Official Journal L, 377.

[58] S Sonak, M Sonak, A Giriyan, 'Shipping hazardous waste: implications for economically developing countries' (2008) 8(2) International environmental agreements: politics, law and economics.

[59] In 1986 operators of the ship Khian Sea, carrying 9000 tons of hazardous waste, misinformed Haiti about the nature of its waste and dumped 3000 tons of hazardous waste on the beach at Gonaives even before the government of Haiti could give permission. After eighteen months the same ship finally appeared in Singapore as Picano. Investigations concluded that the 3000 tons of hazardous waste were illegally disposed of in the Indian Ocean. For more see: HNQ Vu, 'The Law of Treaties and the Export of Hazardous Waste' (1993-1994) 12 UCLA Journal of Environmental Law and Policy, 389.

[60] HNQ Vu, 'The Law of Treaties and the Export of Hazardous Waste' The Comment, 393.

[61] See: 'Being wise with waste: the EU's approach for waste management' Publications Office of the European Union 2010, 3. A discussion of this lies outside the scope of this article.

[62] See Topham/McMillan 472, 470-480; N Andersen, O Eriksson, K Hillman and M Wallhagen; *DTU International Energy Report 2014 Wind energy - drivers and barriers for higher shares in the global power generation mix*, editors Hans Hvidtfeldt Larsen and Leif Sønderberg Petersen (DTU National Laboratory for Sustainable Energy, November 2014); K Ortegon, LF Nies, JW Sutherland, 'Preparing for end of service life of wind turbines' (2013) 39 J. Clean. Prod. 191.

[63] European Commission, Growth - Internal Market, Industry, Entrepreneurship and SMEs, 'Ecodesign'available at http://ec.europa.eu/growth/industry/sustainability/ecodesign_en [accessed 23/Oct/2017].

[64] See, for instance, https://www.ellenmacarthurfoundation.org/news/new-circular-design-guide-launched [accessed 20/Oct/2017].

implications and which recommendations can be made to improve the interlinkage between decommissioning and waste laws.

Is the Current Legal Framework Governing Offshore Wind Farm Decommissioning fit for Waste Management Purposes?

International Law Framework

To ensure safety of navigation and protection of the marine environment, it is important that exploitation of offshore energy resources is followed by a decommissioning process that causes as little environmental impact as possible. The international obligations on decommissioning of offshore installations are mainly governed by the United Nations Convention on the Law of the Sea (UNCLOS) 1982. The Convention entered into force in 1994 and both the UK and Denmark ratified it.[65]

The requirements for countries in respect of abandoned and disused installations or structures to be removed in the exclusive economic zone[66] are set out in article 60(3) of UNCLOS.

> '(…) *Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organization. Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed*.'

The 'competent international organization' for the purposes of article 60(3) of UNCLOS is the International Maritime Organization (IMO)[67] and, in particular, its Maritime Safety Committee.[68] This body produced guidelines on the removal of offshore installations and structures on the Continental Shelf and in the exclusive economic zone, which the IMO adopted in 1989 (Resolution A.672(16)).[69] The guidelines state that 'abandoned or disused

[65] The idea behind UNCLOS is that a person who constructs, extends, operates or uses an installation should be responsible for ensuring that the installation is decommissioned at the end of its useful life and for meeting the costs of decommissioning (the 'polluter pays' principle). See Faber Maunsell & Metoc, Scottish Marine SEA: Environmental Report Section C Chapter 21, 2.

[66] The exclusive economic zone is discussed in Part V of UNCLOS (articles 55-75). It refers to an area up to 200 nm from the baseline. UNCLOS includes detailed provisions concerning these zones and with article 60 includes a particular provision on the administration of installations in this zone. As opposed to this, the regulations on the territorial sea (up to 12 nm, see UNCLOS Part II) where many offshore wind turbines are located, does not feature a similar provision, because the administration of installations in that area is subject to the sovereign regulation of coastal states. It is, thus, not discussed in this section which assesses international law obligations. For more details see: S Bateman, 'Security and the Law of the Sea in East Asia: Navigational Regimes and Exclusive Economic Zones' in D Freestone, R Barnes and D Ong (eds) *The Law of the Sea: Progress and Prospects* (Oxford University Press 2006) 379/380.

[67] The IMO is an agency of the United Nations, which was established by the Inter-Governmental Maritime Consultative Organization Convention of 1948.

[68] International Maritime Organization, 'Implications of the United Nations Convention on the Law of the Sea to the International Maritime Organization', 7-8, available at http://www.imo.org/en/OurWork/Legal/Documents/LEG%20MISC%208.pdf [accessed 17/Oct/2017].

[69] Resolution A.672(16), adopted 19 October 1989 'IMO Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and the Exclusive Economic Zone' (hereinafter: IMO

offshore installations or structures on any continental shelf or in any exclusive economic zone are required to be removed'.[70] Under UNCLOS, countries are required to consider these IMO guidelines. The IMO standards require abandoned or disused offshore installations or structures to be removed in general, but allow for exemptions in specific circumstances.[71] Such exemptions may apply in cases where the structure has no potential effects on navigation and environment or costs are too high or non-proportional risks to personnel are involved.[72] But resolution A.672(16) provides that where an abandoned or disused installation or structure stands in water of less than 100 m deep and weighs less than 4,000 tonnes in air, it should be removed entirely.[73] In any case, these Standards and Guidelines are not legally binding: the IMO Assembly resolution adopting them simply 'recommends' to take these guidelines into account.[74]

The 'post-decommissioning' phase of waste reuse, recycling and disposal is not explicitly acknowledged by the IMO Guidelines and the word 'waste' does not feature in it.[75] However, there is one provision, section 3(13) of the Annex to the Guidelines, which could provide inspiration for the possible future inclusion of waste management aspects. Section 3(13) requires that from 1998 onwards no installation or structure should be placed on any continental shelf or exclusive economic zone unless the design and construction of the installation or structure is such that entire removal, abandonment or permanent disuse would be feasible. This 'design for decommissioning'-provision together with article 60(3) UNCLOS suggest that wind turbines, which by nature are not as heavy and large as oil and gas installations, have to be removed entirely. The provision shall make the decommissioning of any offshore installation more straightforward. A similar 'circular design'-provision could be included during a revision of the IMO Guidelines to improve the waste management of offshore wind farms.

The EU, the UK and Denmark are all contracting parties to the OSPAR Convention, which has a bearing on the decommissioning of offshore installations.[76] OSPAR is the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic, which started in 1972 with the Oslo Convention against dumping and was broadened to cover land-based sources of marine pollution and the offshore industry by the Paris Convention of 1974.[77] These two conventions were unified, updated and extended by the 1992 OSPAR

Guidelines).

[70] Although the Guidelines were principally produced for the offshore oil and gas industry, there is no reason why they should not be applicable to offshore wind turbines and other associated structures as well.

[71] These are potential effects on navigation and environment, as well as cost aspects, risks to personnel involved or any new use of the structure, see IMO Guidelines para. 2.1 and 3.5. Although the possibility of a partial removal is generally envisaged, Resolution A.672(16) provides that where an abandoned or disused installation or structure stands in water of less than 100 m deep and weighs less than 4,000 tonnes in air, it should be removed entirely.

[72] IMO Guidelines, para 2.1.

[73] According to IMO Guidelines, para 3.5 an exemption is possible in cases where complete removal is 'not technically feasible or would involve extreme cost or unacceptable risk to personnel or the marine environment.'

[74] IMO Guidelines, para 1.2.

[75] However, section 2(3) of the Annex to the IMO Guidelines points out that the determination of any potential effect on the marine environment should, inter alia, take the potential for pollution or contamination of the site by residual products from the offshore installation into account. This can apply to liquids such as gear or motor oils and any other chemicals that can be present in the turbine. They can either be collected and removed for later treatment under the applicable waste laws or left inside the nacelle to minimize spillage risk and be collected once onshore, see Topham/McMillan 472.

[76] Pearson; O'Hara 124.

[77] OSPAR Commission 'About OSPAR' available at www.ospar.org/about [accessed 11/Oct/2017]; O'Hara 124.

Convention to which fifteen countries are party and which is named after the original Oslo and Paris Conventions ('OS' for Oslo and 'PAR' for Paris).[78] The purpose of OSPAR is to protect the marine environment and it touches on decommissioning in the sense that the Convention defines dumping to include the deliberate disposal of offshore installations (…), but allows, inter alia, the leaving in place of all or part of a disused installation, provided this is not contrary to international law.[79]

In February 1999 OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations entered into force.[80] This Decision is legally binding for OSPAR contracting parties.[81] The Decision states at no point that it is only concerned with offshore oil & gas installations and does not cover offshore windmills. In fact, the title of the Decision appears to be broad enough to encompass offshore wind farms. However, when reading Decision 98/3 in the context of the OSPAR Convention, it becomes clear that the Decision only applies to offshore installations that are dealing with hydrocarbons.[82]

Regarding the waste from offshore wind farms, the OSPAR Commission issued a guidance document on environmental considerations for offshore wind farm development in 2008.[83] Nonetheless, a guidance document is a recommendation to the Contracting Parties that has no legally binding force.[84] The Guidance states that after the wind farm components have been removed, one has to care about their subsequent disposal (in the sense of reuse, recycling and final residue disposal on land) - so both phases (removal and disposal) are brought together in close connection.[85] In fact, the guidance document always refers to 'removal and subsequent disposal of a wind farm'.[86] In para. 90 it specifies the components that have to be considered when it comes to removal and subsequent disposal. These are:

- wind installation comprised of rotor (with blades and hub), nacelle (containing e.g. rotor shaft, gear, generator, cooling units (containing oil)), tower and foundation (e.g. monopile, tripod, gravity based);
- scour protection materials;
- interconnecting power cables within the wind-farm;
- power cable to shore;

[78] Ibid.

[79] Article 1(g) OSPAR Convention, available at www.ospar.org/site/assets/files/1290/ospar_convention_e_updated_text_in_2007_no_revs.pdf [accessed 11/Oct/2017] (hereinafter: OSPAR Convention).

[80] OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations available at www.ospar.org/documents?v=6875 [accessed 11/Oct/2017] (hereinafter: Decision 98/3).

[81] Art. 13(2) OSPAR Convention.

[82] The term 'offshore installation' is not defined by Decision 98/3, but the OSPAR Convention defines it in article 1(l) OSPAR Convention as 'any man-made structure, plant or vessel or parts thereof, whether floating or fixed to the seabed, placed within the maritime area for the purpose of **offshore activities**' (emphasis added). 'Offshore activities' are defined by article 1(j) OSPAR Convention as 'activities carried out in the maritime area for the purposes of the exploration, appraisal or exploitation of liquid and gaseous hydrocarbons'. Thus, only hydrocarbon-related activities are recognized. In addition, OSPAR Commission themselves are saying that Decision 98/3 only applies to disused offshore oil and gas installations, see para. 92 OSPAR Commission 'OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development (Reference number 2008-3)' available at https://www.ospar.org/documents?d=32631 [accessed 11/Oct/2017].

[83] OSPAR Commission 'OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development (Reference number 2008-3)' available at https://www.ospar.org/documents?d=32631 [accessed 11/Oct/2017] (hereinafter: OSPAR Guidance).

[84] Article 13 (5) OSPAR Convention.

[85] Para. 89 OSPAR Guidance.

[86] See for instance para. 90 OSPAR Guidance.

- converter stations with technical equipment and foundation.[87]

The Guidance states in para. 93 that:

> *In line with OSPAR's policy on waste disposal at sea, the removed components of a wind farm should generally be disposed of entirely on land taking into account the waste management hierarchy of avoidance, reduction, reuse, recycling, recovery, and residue disposal. If the competent national authority decides that a component of the wind farm should remain at site (e.g. parts of the piles in the sea-bed, scour protection materials), it should be ensured that they have no adverse impact on the environment, the safety of navigation and other uses of the sea. The status of remaining parts should be monitored and if necessary, appropriate measures should be taken.*

In addition to this clear reference to the waste hierarchy, the guidance also explicitly provides that the suitable body shall ensure the availability of adequate financial reserves (e.g. bonds) to enable the appropriate removal and subsequent disposal on land (in the sense of the waste management hierarchy).[88]

European and National Law Frameworks

A) EU Law

The next step after the international legal framework for decommissioning and disposal is European and national law. Regarding EU law, whereas there is a considerable amount of legislation concerning waste management, there is no legislation on decommissioning of offshore wind farms.[89] This is extraordinary, as it means that the Renewable Energy Directive does not contemplate at all that Renewable Energy Installations would need to be decommissioned. Either this is a lack of regulatory foresight, or the European Union simply did not want to regulate this matter at EU level and leaves the regulations concerning decommissioning of offshore renewable energy installations to the Member States, in line with the principle of subsidiarity.[90] Be that as it may, in both cases we need to look at national laws to obtain more details on decommissioning and waste management.

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[87] Ibid.

[88] Para. 96 OSPAR Guidance.

[89] The only Directive that regulates the construction of renewable energy installations is the Renewable Energy Directive, Directive (EC) 2009/28 of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16. However, this Directive does not mention decommissioning. By analogy, for oil and gas exploitation, only the Offshore Safety for Oil and Gas Operations Directive (Directive (EU) 2013/30 of 12 June 2013 on safety of offshore oil and gas operations and amending Directive 2004/35/EC [2013] OJ L 178/66) mentions decommissioning. In its preamble 24 it notes that 'an offshore regime needs to apply (…) to the lifecycle of exploration and production activities from design to decommissioning and permanent abandonment'. The definition of offshore operations provided in article 2(3) explicitly includes decommissioning. This is supplemented by Annex I section 5 to the Directive, which clarifies that crucial information on decommissioning of offshore installations has to be made available to the regulator. However, from the title of the Directive, it is clear that this legislation cannot be applied to offshore wind farms.

[90] The principle of subsidiarity, entailed in article 5 (3) TFEU, prescribes that the EU shall act in areas of shared competence, only if and insofar as objectives of a regulatory action cannot be sufficiently achieved by Member States. More can be found at Craig/De Burca 94/95.

B) Denmark

Denmark was the earliest developer of offshore wind energy in Europe.[91] Recently, it was announced that its first offshore wind farm, Vindeby, will be decommissioned. This offshore wind farm, located 1,5 to 3 km offshore in the Danish territorial sea, produced energy for 25 years and is now at the end of its planned lifetime.[92] The decommissioning of Vindeby provides an interesting example of decommissioning and windmill waste management in practice in Denmark.

In the case of Vindeby, constructed before the coming into force of the current centralized tender system that will be discussed below, the decommissioning obligation is based on the construction licence. In a letter which formed the basis for the later construction licence, the Traffic Ministry, which was the responsible authority for offshore wind energy in 1989, stated that it was not possible to construct an offshore wind farm without prior permission by the said Ministry.[93] This letter included specific conditions regarding decommissioning[94] The letter is now used as the legal basis for the decommissioning of Vindeby.[95]

The modern decommissioning obligation for younger wind farms is entailed in the Model Construction Licence. This License is required under the Danish Renewable Energy Act (*lov om fremme af vedvarende energi*)[96] for the construction of an offshore wind farm. The award of this license can be made subject to conditions by the Minister for Energy and Climate.[97] The conditions can cover several technical and safety-related topics, one of which is decommissioning.[98]

In the current system of centralized tendering for offshore wind farms, the tender conditions that are prepared by the Danish Energy Authority include a Model Construction License which contains decommissioning conditions.[99] The legal value of the Model Construction

[91] Denmark developed Vindeby in 1991. The next 'offshore' wind farm to be developed was Lely, in the IJsselmeer, a lake in the Netherlands, in 1994. See for a complete overview: EWEA 'Operational Offshore Farms' (EWEA 2009) available at <www.ewea.org/fileadmin/ewea_documents/documents/statistics/OperationalOffshoreFarms2009.pdf> accessed 14 August 2017. [accessed 14/Sep/2017].

[92] *Supra* footnote 6.

[93] Letter from the Traffic Ministry dated 20 November 1989, quoted directly in the Approval for Decommissioning, Danish Energy Agency (Energistyrelsen), J-2017-176, 7/8, 10 January 2017, available at https://ens.dk/sites/ens.dk/files/Vindenergi/tilladelse_til_nedtagning_af_vindeby_havvindmoellepark.pdf [accessed 14/Aug/2017].

[94] Ibid. Elkraft (the owner of the wind farm and addressee of the permit) is obliged to remove the plant or remnants of it at its own expense and to (re)establish the area in its previous condition in certain cases, namely if the plant is not maintained or destroyed, if the plant is no longer used as a wind farm, if conditions for permission are not met or observed or if the circumstances suggest this, an observation at the Ministry's discretion.

[95] Ibid.

[96] Lov om fremme af vedvarende energi, latest version: LBK nr. 1288, applicable since 27-10-2016, www.retsinformation.dk/Forms/r0710.aspx?id=184376 (hereinafter Renewable Energy Act). For the entire construction and operation process, one needs a pre-investigation licence (sec. 22 Renewable Energy Act), a construction licence (sec. 25 Renewable Energy Act), a license to exploit the wind power (sec. 29 Renewable Energy Act) and an authorisation to produce electricity under the Electricity Supply Act (*Lov om elforsyning*) LBK nr. 418, applicable since 25-4-2016, https://www.retsinformation.dk/forms/R0710.aspx?id=174909.

[97] Renewable Energy Act, Sec. 25(3).

[98] Ibid., Sec. 25(3) 'nedtagning og sikkerhedsstillelse for nedtagning af anlæg'.

[99] Cf. Energistyrelsen, Tender Conditions for Kriegers Flak Offshore Wind Farm (Final Draft, 8 July 2016), (hereinafter: Energistyrelsen, Tender Conditions)

Licence is that it becomes binding for the winner of the tender, which is the future owner and operator of the offshore wind farm. The Model License reads:

> *'The Concessionaire is obliged, at its own account, to restore the area to its former condition, including to carry out the necessary remediation and clean up in the area, as well as to decommission and dispose the electricity production plant pursuant to a decommissioning plan approved by the Danish Energy Agency'.*[100]

For the decommissioning process itself, another permit under the same provision of the Danish Renewable Energy Act is needed, a permit for substantive changes to existing installations, also awarded by the Danish Energy Authority (*Energistyrelsen)*.[101] The wind farm owner prepares a decommissioning plan at latest two years before the decommissioning takes place.[102] This decommissioning plan serves as a basis for the permit for substantive changes.[103] Interestingly, the requirements for decommissioning as stated in the tender conditions and the Model Construction License mention 'decommission and dispose' without further specifying the requirements for this disposal. Moreover, they do not mention waste management at all. Nevertheless, in the only decommissioning plan available for Denmark,[104] the decommissioning plan for Vindeby, waste management is accurately addressed, according to the waste hierarchy.[105] First, it is mentioned that, depending on their condition, several parts will be reused in other turbines of the same type.[106] Then, several parties are mentioned that are interested to take over a complete wind turbine or large parts, such as wings or the gearbox.[107] These parties are not interested in reuse in other wind turbines, but rather in research into the wear and tear of the materials. Materials that cannot be reused will be scrapped and recycled by certified companies.[108] The decommissioning plan is very detailed here, in that it mentions specific companies that will be contracted for specific materials (iron, concrete etc.). Another form of recovery is also addressed: it is suggested to use the marine growth on the foundations (macroalgae; seaweed), weighing an estimated 5-14 tonnes, as a fertilizer for nearby farming fields.[109]

As there is no specific requirement in the construction licence conditions for incorporation of waste management in the decommissioning plan, the detailed description of the waste management is based on general Danish waste law. This legislation has to be examined

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[100] Energistyrelsen, Tender Conditions for Kriegers Flak Offshore Wind Farm (Final Draft, 8 July 2016), (hereinafter: Energistyrelsen, Tender Conditions) 85 (Draft Model Construction License), 124 (Model Authorisation for the production of electricity). See also Energistyrelsen, Betingelser for udbud af etablering af havmølleparken Horns Rev 3, 6 February 2014, 59-60 (similar provision but in Danish).

[101] Renewable Energy Act, Sec. 25(1). eg Energistyrelsen, 'Tilladelse til nedtagning af Havvindmølleparken ved Vindeby' (Letter to DONG, in Danish) 10 January 2017. This article also applies to offshore installations used for the production of electricity from the water.

[102] Energistyrelsen, Tender Conditions for Kriegers Flak Offshore Wind Farm (Final Draft, 8 July 2016), (hereinafter: Energistyrelsen, Tender Conditions) 56, 85 (Draft Model Construction License) 125 (Model Authorisation for the production of electricity).

[103] Eg B Hansen (DONG Energy), Nedtagningsplan for Vindeby Havmøllepark (DONG, Oct 2016) in Danish, available at https://ens.dk/sites/ens.dk/files/Vindenergi/nedtagningsplan_for_vindeby_havmoellepark_final_update_okt.pdf [accessed 02/Oct/2017] (hereinafter Decommissioning Plan Vindeby).

[104] The other offshore wind farms are not yet within 2 years of their decommissioning date, which is the moment the decommissioning plan is drafted and publicised.

[105] Decommissioning Plan Vindeby, 13-15.

[106] Ibid., 15.

[107] Ibid., 15.

[108] Ibid., 15.

[109] Ibid., 17.

further in order to discover which obligations are applicable to the decommissioning and disposal of Danish wind farms, beyond the Vindeby case.

Strongly influenced by EU waste law, [110] industrial waste management in Denmark is regulated by the Environmental Protection Act[111] and the Executive Order on Waste[112] which have been amended by Law No 369 of 1999[113] to include provisions from the IPCC, and further amended by Statutory Order 162 of 2015[114] to include provisions brought by the Industrial Emissions Directive (IED).[115] Regarding the offshore industry, the Act on Protection of the Marine Environment[116] is of main relevance. According to this act, which aims to prevent and limit pollution and other impacts on nature and the environment, it is obligatory for the offshore operators to apply for permits for the use and discharge of offshore chemicals to the sea.

Special rules apply to the management of hazardous waste and are specified in the Executive Order on Waste.[117] The Order provides that the operator must keep a register to keep track of the amounts of hazardous waste produced. As an example, in the decommissioning plan for Vindeby, prior to the licensing and final choice of dismantling, DONG Energy has commissioned a survey of environmentally harmful substances in the wind farm structural components. The analysis showed the presence of heavy metals in different concentrations in the paint, tower structures, and in the flange between the turbine and the foundation. An overview of the structural components of the wind farm containing environmentally hazardous substances was made and the type of waste and waste management recommended was indicated in the decommissioning plan. DONG states in the decommissioning plan that the dismantling work will be done according to the outcome of the identification of environmentally harmful substances, which is reflected in the description of the removal and handling, and subsequent recovery of wind farm components.[118] The wind farm operator that produces these hazardous wastes must report the waste to the municipal council when it comes to the shore.[119] Documentation for this information must be kept for 3 years. Waste carriers transporting hazardous waste and dealers and brokers of hazardous waste shall, at the request of the Danish Environmental Protection Agency or the municipal council, provide information from the register and documentation for this information.[120]

In conclusion, an analysis of Danish decommissioning and waste management law and the practical example of the decommissioning plan for Vindeby show that, whereas waste management is not mentioned in the provisions on decommissioning, it is taken into account in practice based on general Danish environmental law. Moreover, in the case of Vindeby, disposal is prevented as far as possible by reuse, recycling and recovery of different

[110] EM Basse, Environmental law in Denmark (The Hague: Kluwer law international, 2000) 58 and 73.
[111] LBK nr. 1317 af 19/11/2015 (Chapter 5).
[112] BEK nr. 1309 af 18/12/2012.
[113] LOV nr. 369 af 02/06/1999.
[114] BEK nr. 162 af 16/02/2015.
[115] Directive 2010/75 on industrial emissions (integrated pollution prevention and control) (Recast) [2010] OJ L334/17.
[116] LBK nr. 963 af 03/07/2013 as amended LBK nr. 1033 of 04/09/2017.
[117] BEK om Affaldsregistret og om godkendelse som indsamlingsvirksomhed.
[118] DONG, Dismantling Plan for Vindeby Offshore Wind Farm: Report (2016) 13, available at https://ens.dk/sites/ens.dk/files/Vindenergi/nedtagningsplan_for_vindeby_havmoellepark_final_update_okt.pdf [accessed 13/Oct/2017] (hereinafter: DONG).
[119] Section 70 Environmental Protection Act LBK nr. 1317 af 19/11/2015.
[120] Section 71 Environmental Protection Act LBK nr. 1317 af 19/11/2015.

materials. Nevertheless, a structural flaw in the Danish system is that waste management is addressed only at a late stage, namely two years before decommissioning takes place, because wind farm owners only have to hand in decommissioning plans by that time. Therefore, waste prevention through design is difficult to implement as it needs to be considered already in early phases of the project. Thus, for 'circular design' to be effectively implemented in Denmark, waste management and waste prevention should already be addressed in the tender phase rather than only in the decommissioning plan.

C) United Kingdom

Currently, the Energy Act 2004 is the legal basis for the decommissioning obligation of offshore renewable energy installations in the UK.[121] Prior to the implementation of the Energy Act 2004, offshore operations had to comply with the Crown Estate's consenting process to meet decommissioning liabilities.[122] The Energy Act 2004 obliges developers to carry out decommissioning.[123] The act also puts into place a comprehensive statutory decommissioning scheme for offshore wind and marine installations as well as cables.[124] Although some amendments have been made by subsequent acts, the core of these obligations remains unchanged.[125] Section 105 (1) and (2) determine that the Secretary of State or the responsible Minister[126] may require persons proposing to construct, or operate a renewable energy installation or electric line offshore, to submit (and eventually carry out) a decommissioning programme.[127] Such a request may already be issued at the proposal stage of a project, according to section 105 (3) Energy Act 2004. In practice, the Department of Energy and Climate Change (DECC) will not allow construction to move forward unless at least a draft decommissioning programme has been submitted to them.[128]

The Energy Act 2004 does not provide guidance on the interaction between decommissioning and waste management.[129] Sections 105 to 114 Energy Act 2004, which are dealing with the decommissioning of offshore energy installations, do not mention waste management and/or 'post-decommissioning' other than monitoring.[130] However, specific details on waste management are included in a guidance note on the decommissioning of offshore renewable energy installations under the Energy Act 2004, which was issued in 2011 by DECC.[131] The

[121] Energy Act 2004, Ch 3 Part 2.
[122] Crown Estate Act 1961, s 1. The decommissioning provisions were set out in the seabed leases from the Crown Estate, necessary to conduct offshore renewable energy production in the UK, see: B Milligan, 'Planning for offshore CO_2 storage: Law and policy in the United Kingdom' (2014) 48 Marine Policy 167 (hereinafter: Milligan).
[123] Energy Act 2004, s. 105.
[124] Energy Act 2004, s. 105-114.
[125] Most notably by Energy Act 2008 Part 3 Chapter 2 s 69-71; Scotland Act 2016, s 62 (10) and (11).
[126] If the installation is in Scottish waters or the Scottish part of the Renewable Energy Zone, the Scottish Ministers have to be consulted as well.
[127] The submission of a decommissioning programme may be requested from more than one person. In this case a joint programme must be submitted. Energy Act 2004s 105(4).
[128] This is the effective meaning of para. 3.8 with 5.7/5.8 DECC, 'Decommissioning of offshore renewable energy installations under the Energy Act 2004: guidance notes for industry' 2004, revised in 2011.
[129] With the notable exception of radioactive/nuclear waste, which is mentioned explicitly in the preamble of the Energy Act 2004. This, however, is due to the fact that nuclear decommissioning and nuclear waste treatment are particular subjects of the Energy Act 2004.
[130] Energy Act 2004, s 105(8)(e) and (d) .
[131] In July 2016 DECC became part of the Department for Business, Energy & Industrial Strategy (BEIS). DECC issued guidance on the decommissioning of offshore windmills, see DECC, 'Decommissioning of offshore renewable energy installations under the Energy Act 2004: guidance notes for industry' 2004, revised in 2011 (hereinafter: DECC Guidance).

DECC guidance notes require decommissioning programmes to be in line with decommissioning standards described in chapter 7 of the guidance note.[132] These decommissioning standards of chapter 7 include a subsection called 'management of waste'.[133] After reiterating the waste hierarchy of reuse, recycling and incineration with heat recovery/disposal,[134] the document takes a stance on the disposal of waste at sea, deeming it unacceptable. However, it also opens up two exceptions for leaving elements of an installation *in situ* and reuse of material at sea.[135]

DECC emphasizes that it does not prescribe exactly the choice of waste management options (in terms of when materials should be reused, recycled or disposed of) that are taken in decommissioning programmes for offshore renewable energy installations.[136] However, developers/owners should have regard to the waste hierarchy, which suggests that reuse should be considered first, followed by recycling, incineration with energy recovery and disposal.[137]

For this article eight different decommissioning programmes of UK offshore wind farms have been analysed and all include sections on waste management.[138] Nonetheless, the vast majority of analysed decommissioning programmes barely commit more than one or two commonplace statements to the topic. The sentence that features in most of the programmes (in a number of varieties) is: '[Company name] commit to following the principles of the waste hierarchy during decommission, along with all relevant legislation at the time', which is often supplemented by a sentence along the lines of 'it is intended that the vast majority of/all elements of the offshore wind farm will be taken back to land for reuse and recycling'.[139] In effect, this amounts to nothing more than reiterating the current legal

[132] DECC Guidance, para. 5.10 and 7.1.
[133] Ibid., paras. 7.23-7.25.
[134] Ibid., para. 7.23.
[135] Ibid., para. 7.24.
[136] Ibid., para. 7.25.
[137] Ibid.
[138] DONG Energy Gunfleet Sands Demo (UK) Ltd. 'Decommissioning Plan' available at http://assets.dongenergy.com/DONGEnergyDocuments/Gunfs/DecommissioningPlan.pdf [accessed 13/Oct/2017] (hereinafter: Gunfleet); Forewind Dogger Bank Creyke Beck 'Outline Decommissioning Statement' available at http://www.forewind.co.uk/uploads/files/Creyke_Beck/Application_Documents/8.3_Decommissioning_Statement_F-DVC-SP-001_FINAL_10-08-13.pdf [accessed 13/Oct/2017] (hereinafter: Dogger Bank); Transmission Capital Ormonde OFTO Ltd 'Decommissioning Programm' available at http://www.transmissioncapital.com/pdf/BD%20ORM%20TEC%20002-2%20Ormonde%20OFTO%20Decom%20Plan%20for%20Publication.pdf [accessed 13/Oct/2017] (hereinafter: Ormonde); Statoil Sheringham Shoal Offshore Wind Farm 'Decommissioning Programme' available at http://www.scira.co.uk/downloads/Decommissioning%20Programme%20SCIRA%20SC-00-NH-F15-00005_07.pdf
[accessed 13/Oct/2017] (hereinafter: Sheringham Shoal); Thanet Offshore Wind Ltd. 'Thanet Offshore Wind Farm Decommissioning Plan' available at https://corporate.vattenfall.co.uk/globalassets/uk/projects/decommissioning-plan-2008.pdf [accessed 13/Oct/2017] (hereinafter: Thanet); Greater Gabbard Offshore Winds Limited 'Decommissioning Programme' available at: http://sse.com/media/92981/GGOWL_DecommissioningProgramme.pdf. [accessed 13/Oct/2017] (hereinafter Gabbard); Blue Transmission Walney 2 Ltd. 'Decommissioning Programme' available at http://www.bluetransmission.com/sitemanager/uploads/files/Walney%202%20Decommissioning%20plan.pdf
[accessed 13/Oct/2017] (hereinafter: Walney 2); Statoil 'Decommissioning Programme for Dudgeon Offshore Wind Farm' available at http://dudgeonoffshorewind.co.uk/about/downloads/Dudgeon%20Decommissioning%20Programme%20v4%20(C177-DOW-A-TB-0001).pdf [accessed 13/Oct/2017] (hereinafter: Dudgeon).
[139] Para. 5.2 Dundgeon; para. 5.5 Walney 2; para. 5.3 Thanet; Para. 3.3 Ormonde; Para.3.1.1 Dogger Bank;

situation.[140] It does not provide any details on how the individual components of the wind farms are intended to be treated, which parts are reused, recycled, and which disposed of and where and when reuse, recycling and disposal is intended to take place.

Still, there are two notable exceptions to this general finding. The decommissioning programme of the Greater Gabbard wind farm entails a spreadsheet detailing the types of waste (e.g. 'Glass-fibre Reinforced Epoxy (GRE) from the blades'), the intended pre-treatment of that particular component ('Break down into transportable size') and the envisaged waste management solution for the particular component ('Recycle').[141]

Similarly, the decommissioning programme for the Gunfleet Sands extension includes a discussion on where exactly suitable waste disposal sites are situated that will be used for 'post-decommissioning'.[142] Moreover, it includes an, albeit shorter and rougher, spreadsheet that explains the individual waste management solutions that are going to be used for the individual components of the wind farm.[143]

Interestingly, these two positive examples cannot be considered as part of a learning curve pattern that is linked to a particular period of time when they were issued ('latest decommissioning programmes'). In fact, the Gunfleet Sands extension programme stems from 2012 and the Greater Gabbard decommissioning programme has already been drawn up in 2007.

As mentioned earlier, all programmes include references to UK waste laws and assert that the companies will comply with those laws in place at the time of decommissioning. Indeed, for DECC 'the key requirement is that waste management must be carried out in accordance with all relevant legislation at the time.'[144] It is thus necessary to provide a brief overview of the relevant UK waste laws to understand the waste management regulations for UK offshore wind farms.

EU waste law has been largely influential in the UK, just as it has been in other EU Member States. The waste related EU Directives and Regulations provide the backbone of the system and have been transposed in the UK through a number of separated pieces of legislation.[145]

The waste producer (the owner of the wind turbine or wind farm under decommissioning process) is obliged to provide a proper destination to the waste produced. This implies

[140] Sometimes this is followed by an explicit list of the relevant UK waste legislation, which is not more than a copy-paste than the list of waste legislation given in the DECC Guidance; examples include Para. 3.1.1 Dogger Bank and Page ii Gunfleet.
[141] Para. 5.7 Gabbard.
[142] Page 12 Gunfleet.
[143] Para. 3.6 Gunfleet.
[144] Para. 7.25 DECC Guidance.
[145] Environmental Protection Act 1990 SI 1990/2226 (Part II); Waste Management Licensing Regulations 1994 (England, Scotland and Wales) SI 1994/1056; Waste and Contaminated Land (Northern Ireland) Order 1997 SI 1997/2778; Pollution Prevention and Control Act 1999; Pollution Prevention and Control (England and Wales) Regulations 2000 England and Wales, SI 2000/1973; Pollution Prevention and Control (Scotland) Regulations 2000 Scotland, SI 2000/323; Pollution Prevention and Control (Northern Ireland) Regulations 2003 Northern Ireland, SR 2013/46; Environmental Permitting Regulations 2007 (England and Wales) SI 2007/3538; Environmental Permitting Regulations 2007 Scotland, SI 2003/71; Environmental Permitting Regulations 2007 Northern Ireland, SR 2003/493; Environmental Permitting (England and Wales) (Amendment) Regulations 2013SI 2013/390; Pollution Prevention Control (Scotland) Regulations 2012 SI 2012/360; Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013 SR 2013/160.

choosing authorized waste management installations, one of the first actions to be taken into fulfilling the requirements to obtain an environmental permit.[146]

Further, following on the WFD section 34 Environmental Protection Act 1990 sets out the Waste Duty of Care (DoC). The principle derives from the 'polluter pays principle' (legal and financial responsibility) for managing waste safely. DoC applies to those who 'import, produce, carry, keep, treat or dispose of controlled waste' from the moment it arrives ashore.[147] Deriving from the DoC principle, Sections 1 and 2 of the Control of Pollution (Amendment) Act 1989 regulate the carriage and transfer of waste. When the waste produced by decommissioning activities arrives ashore it requires transportation to a site for disposal or recovery. The Act sets out the statutory obligations of those who transport waste, and adds to the list of regulations that affect waste management by waste producers, including wind farms under decommissioning. Establishments and undertakings that collect or transport waste on a professional basis or that arrange for the disposal or recovery of waste (dealers or brokers) also must have a registration with the Environment Agency as waste carriers.

The Hazardous Waste Regulations 2005 sets requirements for the notification of most premises that produce hazardous waste to the Environment Agency and the tracking of the waste from the point of production until it reaches a suitably permitted waste management facility by way of a consignment note. Hazardous waste is a reality in the decommissioning process of wind farms as, for instance, the paint used to resist in the sea contains heavy metals, as discussed earlier.[148]

Concerning shipments, the Transfrontier Shipment of Waste Regulations 1994[149] specified administrative procedures, penalties and offences.[150] Prevention of illegal shipments of waste from decommissioned offshore wind turbines, especially to countries outside the EU where legislation on the matter is less strict or inexistent, is a great concern here.

Finally, a word has to be said on financial arrangements: paragraph 96 of the OSPAR Guidance (discussed in the international law section above) recommends to Contracting Parties (the UK is one) to make arrangements for the licensee to have adequate financial reserves (e.g. bonds) available for the disposal on land in the sense of the waste management hierarchy. The DECC guidance notes include chapter 8, providing details on financial security arrangements that DECC expects. However, specifics concerning financial security for waste treatment are not given there.[151] In a similar vein, financial securities specific for waste treatment are not mentioned in any of the scrutinized decommissioning programmes for UK offshore wind farms.

Conclusion

Windmills might not generate waste while they are producing, as the initial statement at the beginning of this article ('windmills do not generate waste')[152] highlights, but once they have

[146]See for instance section 14 Environmental Permitting Regulations (England and Wales) 2007 SI 2007/3538.
[147] Section 34 (1) Environmental Protection Act 1990.
[148] DONG 13.
[149] SI 1994/1137.
[150] These Regulations are linked to Waste Shipment Regulation (originally Regulation [EEC] No 259/93) which, in its turn, is the transposition by the EU of the Basel Ban decision of 1994 (Decision III/1).
[151] See DECC Guidance, chapter 8.
[152] Supra footnote 1.

to be decommissioned, they become waste themselves, which has to be treated. This, however, is not often taken account of, let alone that possibilities to treat and/or avoid waste from offshore windmills have been discussed in the legal literature. When looking into the issue, we identified three recommendations that could be made to improve the dual frameworks of waste regulation and decommissioning norms that are currently governing the treatment of waste from offshore wind turbines.

First, it would be desirable to improve and enrich international law documents with a 'circular design principle'. Such a principle could build on the 'design for decommissioning' provision in the IMO Guidelines. The requirement for 'circular design' of offshore wind turbines could be incorporated in a provision of the IMO Guidelines and the OSPAR Guidance. As explained in the article, the main goal of circular design is to force producers to develop more efficient and environmentally-friendly products to reduce energy and resource consumption.

Second, national law on the decommissioning of offshore wind farms should take better account of waste management. In this respect, we suggest to improve individual offshore wind farm decommissioning programmes with more detailed provisions on intended waste management arrangements (UK). Moreover, waste management arrangements should be considered earlier, that is, already in the wind farm design phase (Denmark). Such an early recognition would allow producers to take full account of the proposed 'circular design'-provision. In order to achieve this, the regulator should prescribe (in laws and/or guidance documents) that wind farm developers have to explain in detail how they intend to treat individual components of the wind farms, which parts are reused, recycled, and which are disposed of and how reuse, recycling and disposal is intended to take place. There is much to say for not prescribing developers/wind farm owners exactly what to do with each component. However, they should be forced to think about this issue already when creating wind farms, because current decommissioning programmes from the UK indicate a rather superficial treatment of that topic at the moment and decommissioning programmes in Denmark are only made a few years before the end of the lifetime of the wind farm.

Third, we are pleading for increased investment in research and development with regard to the disposal of windmill waste, specifically in the waste management of the fibre-reinforced windmill blades, which are a growing recycling problem. Although the Landfill Directive does not prevent those from being sent to landfills, the waste hierarchy and a goal for reduction of waste require better solutions than the options currently available. This is an essential step, as without options to improve waste management in practice, increased attention to waste management in decommissioning plans will not lead to concrete progress.

The increasing number of wind farms that have to be decommissioned in the following years brings pressure for a clear structure concerning waste treatment. Such a structure should include specific responsibilities for all actors in the life-cycle of offshore wind turbines and contribute to perfection of practices, investments in technology and recycling design. This should result in the development of an environmentally correct and safe management of this waste.